The Mathematics Survey: A Tool for Assessing Attitudes and Dispositions

The need for positive attitudes and dispositions permeates the teaching and learning of mathematics. What students believe about mathematics influences what they are willing to say publicly, what questions they are likely to pose, what risks they are willing to take, and what connections they make to their lives outside the classroom (Borasi 1990; Whitin and Whitin 2000). Unless students have a realistic sense of mathematical applications in real-life contexts, they are unlikely to see themselves pursuing courses in advanced mathematics or choosing mathematics-related careers (Picker and Berry 2001).

Principles and Standards for School Mathematics (NCTM 2000) delineates a range of attitudes and beliefs about mathematics that contribute to productive problem solving and communication. For example, perseverance, curiosity, confidence, and flexible thinking are related to learners' investment in challenging problem solving and investigations involving complex patterns and relationships. Confidence, open-mindedness, a willingness to share one's own successes and failures, and the ability to shift perspectives are hallmarks of meaningful communication. Resourcefulness and reflective analysis are important dimensions in learners' ability to use various forms of representation to generate, clarify, and express thinking.

Given the ways in which mathematical attitudes, skills, knowledge, and strategies are intertwined, assessing students' attitudes and beliefs can provide valuable information, especially at the beginning of the school year. The results can be used to guide the development of a classroom environment conducive to growth in positive attitudes and in addressing misconceptions and counterproductive beliefs (Picker and Berry 2001; Rock and Shaw 2000). This article describes the development and implementation of a mathematics attitude survey designed to meet this need. Examples of fourth-grade children's responses to the survey over a four-year period, the ways in which the results guided teaching and learning, and an analysis of post-assessments illustrate the process.

The Mathematics Survey as a Tool for Assessment

The mathematics survey (**fig. 1**) is composed of six sentence-completion prompts designed to elicit children's perceptions of what constitutes mathematical knowledge, ways of thinking, and usefulness in everyday life. It was adapted from the Burke Reading Survey (Goodman, Watson, and Burke 1987) and correlates with attitudes identified by NCTM (2000). Prompts 1, 2, 3, and 5—"To be good in math, you need to ... because ..."; "Math is hard when ..."; "Math is easy when ..."; "The best thing about math is ..."—are included to encourage responses that reflect the degree of students' confidence, curiosity, flexible thinking, and their views of student-teacher and student-student relationships. The fourth prompt—"How can math help you?"—addresses students' perceptions about the usefulness of mathematics and real-life applications. The final prompt—"If you have trouble solving a problem in math, what do you do?"—is intentionally somewhat ambiguous so that the students can reveal their definitions of, attitudes toward, and strategies for problem solving.

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The following questions guided the analysis of student responses:

- What do these responses reveal about students' perceptions regarding the teacher-student relationship? Regarding student-student relationships? Do references to the teacher imply that the teacher is the sole source of knowledge? Is there evidence of student autonomy? Of collaborative thinking? Are other students mentioned? If so, in what ways?
- What do these responses reveal about students' perceptions regarding mathematical content and applications? Do students cite examples of functional applications of mathematical ideas? Do they view mathematics as valuable and relevant in both the present and the future?
- What do these responses reveal about students' perceptions regarding processes of engaging in mathematical investigations (e.g., planning, reasoning, using strategies in a flexible manner, making connections, representing ideas in multiple ways, collaborating, discovering patterns and relationships)? Do the students view challenge as rewarding?

Examples of typical responses collected from the four fall surveys illustrate the assessment process (see **fig. 2**). In these examples, words and phrases about listening, paying attention, and studying suggest a belief that mathematics is a silent and solitary endeavor. The responses suggest that these children view mathematics class as a period of teacher-student interchanges in which the teacher poses questions or problems and evaluates answers. The children do not usually mention their peers except in a negative sense, such as "talking to other people" rather than "paying attention." To be a successful mathematics student, one must listen to the teacher, follow directions, and study. Responses such as this to prompt 1—"study real hard because you need to know the problems in a flash"—also imply that speed is a universal measure of mathematical success. References to extended investigations are absent. Similarly, each year about half the responses to prompt 6—"If you have trouble solving a problem in math, what do you do?"—suggest

Figure 1

Mathematics survey

1. To be good in math, you need to ... because ...
2. Math is hard when ...
3. Math is easy when ...
4. How can math help you?
5. The best thing about math is ...
6. If you have trouble solving a problem in math, what do you do?

Tell anything else you want about math.
On the back of your paper, draw a picture that shows what math means to you.

Figure 2

Typical student responses from the fall mathematics surveys

1. **To be good in math, you need to ... because ...**
   "study and do all your papers"
   "concentrate and don't play around because if you don't concentrate you will do bad"
   "study and listen because you might not know what to do"
   "study real hard because you need to know the problems in a flash"
2. **Math is hard when ...**
   "it's 2-digit division"
   "you don't listen, not pay attention, or talking to other people"
   "you don't concentrate"
   "you don't follow directions"
   "you can't understand what the teacher says"
3. **Math is easy when ...**
   "you work good by listening to the teacher"
   "when you have studied really hard"
   "when it's times or plus"
4. **How can math help you?**
   "when you get good grades and not get on restriction"
   "when you go to the store"
   "when you get a job"
   "when you get an A"
   "If you saw two numbers and if you wanted to do something with the numbers."

...

6. **If you have trouble solving a problem in math, what do you do?**
   "Raise your hand and ask the teacher."
   "Ask for help."
   "I skip it and do the next one."

that students depend on the teacher for direction (e.g., "raise your hand," "ask the teacher"). Other responses such as the one suggesting skipping the problem imply time management. Only rarely do students describe devising an alternative method, collaborating, or using various forms of representation as problem-solving strategies.

In response to prompt 4—"How can math help you?"—the children's statements indicate that the rewards of engaging in mathematical activity are extrinsic—for example, getting good grades and maintaining good relationships with parents. Almost exclusively, students do not mention the intrigue or challenge of investigations as rewarding or "fun." Few students mention mathematics as useful in the present; most give vague references to college or employment in the distant future. Although some children cite using money as a helpful part of mathematics, others mention computational activity that is devoid of any context, such as the student who suggested seeing "two numbers" and "wanting to do something" with them.

The patterns that emerged from the survey analysis illuminate a range of attitudes and beliefs that could interfere with students' mathematical growth. Identifying these trends served to guide plans for structuring the environment, designing instructional activities, and delineating the teacher's role. **Figure 3** shows a summary of the trends from the fall surveys; productive attitudes, dispositions, and beliefs about mathematics (NCTM 2000); and plans for teaching and learning.

Using the Results of the Survey

Changing the view of mathematics as a solitary endeavor entailed structuring group problem-solving tasks, promoting collaborative conversations, and encouraging the children to view their peers as resources. In the case of these fourth graders, the teacher decided that beginning the year with a noncomputational activity, such as pentominoes or classification with attribute blocks, could help expand the children's limited views of mathematics as computation. Further, a puzzle or game format could highlight for the children that all mathematical activity is not done "in a flash" or by following a prescribed procedure. As pairs or small groups of children worked together to solve puzzles, their conversations laid an important foundation for writing and visual representation (Huinker and Laughlin 1996; Whitin and Whitin 2003; Wickett 1997). At the completion of the task, the teacher conducted a reflective conversation that specifically addressed the targeted dispositions. She posed questions such as these: "What was going through your mind when you first started the puzzle?" "How did your group's ideas help you?" "What did you do if your first idea didn't work?" Many children were surprised to find that their peers encountered frustration or that the teacher did not regard their building off a classmate's suggestion as "cheating."

Following the conversation, the teacher asked the children to record their discoveries about their learning processes in writing and to name specific children whose thinking helped them—for example, "Catherine helped me when she said, 'Switch them around.'" Public acknowledgment of collaborative efforts and written reflections about problem-solving processes continued throughout the year (Whitin and Whitin 2000). **Figure 4** shows one student's representation of the value of mathematical conversations. The first box shows a red and a blue circle, representing two children's ideas. During the conversation, the two ideas begin to blend (second box) until finally they merge into one purple circle in which "the class works together and

the ideas get mixed." The student's summary—"I think math is easier when our class puts our ideas together"—demonstrates a marked change in attitude from such presurvey comments as "Math is easy when it's times or plus."

To build the students' confidence and self-reliance, the teacher needed to shift attention away from herself as dispenser of knowledge. To achieve this goal, she carefully examined the implicit messages conveyed through her interactions with the students. She made conscious efforts to respond to the children's questions and comments in ways that invited revisiting or extending a problem (Schwartz 1996). If the students asked, "Is that right?" the teacher, to encourage them to revisit their thinking process and either confirm or revise their solution, would respond, "How can you be sure?" or "Explain your thinking." When the children shared a conjecture—for example, "When you add two odd numbers, you get an even number"—the teacher invited further investigation by asking, "Does that always work?" If a child raised a question during a class discussion, the teacher developed the habit of turning the question over to the group. In addition, she learned to carefully choose words that conveyed resourcefulness and curiosity—for example, *invent* or *discover* rather than *find* or *use*.

Regularly using student-authored problems for homework and a morning "problem of the day" were additional ways to increase the children's confidence. Over time, the teacher strove to feature as the "problem of the day" an original problem written by every child in the class. As part of the ritual, the student-author led the discussion of the problem's solution (Whitin and Whitin 2000). On other occasions, the children expanded on entries in their mathematics journals and "published" their findings for parents and other classes. In these ways the children had opportunities throughout the year to view one another as resources, develop their confidence, and feel recognized and rewarded for their learning.

Instituting a mathematical forum where students shared their problem-solving strategies served to develop the children's flexible thinking. When one child demonstrated his use of the distributive property, for example, the teacher suggested that the other students work in groups to apply his strategy to a variety of problems and later share their discoveries. The teacher also introduced the students to problem posing (Brown and Walter 1990). Sometimes she planned problem-posing explorations in advance (Whitin forthcoming), and on other occasions she built on children's spontaneous questions, such as, "If $4 \times 3 = 3 \times 4$, why doesn't $34 \times 3 = 33 \times 4$?" This question inspired an investigation of the commutative property in multiplication, as well as the problem-posing extension, "Are there similar multiplication problems that *do* yield the same product? What are the attributes of the problems that do 'work'?" In pursuing these extensions, one child found that 22×3 equaled 33×2. Following the pattern of using a two-digit number with the same number of tens and ones, she tried 33×6 and 66×3. When she discovered that the strategy worked, she wrote: "When I wrote down the problems I didn't know if I would get the same answer or not. I used these numbers because $3 \times 6 = 18$ and $6 \times 3 = 18$." Her statement conveys her willingness to take risks, her resourceful thinking, and her sense of personal accomplishment. These

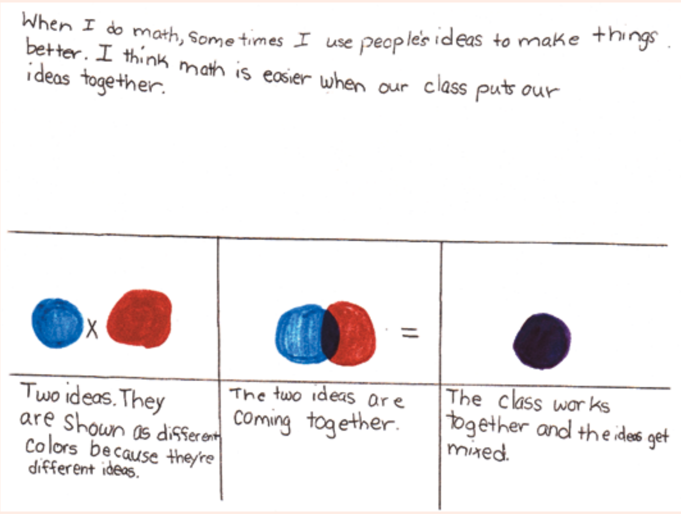
Figure 3

Using the analysis of survey results to guide instructional plans

Trends Implied by the Surveys	Positive Attitudes, Dispositions, Beliefs	Instructional Plans for Change
1. Mathematics is a solitary, silent endeavor.	1. Collaboration and communication contribute to mathematical understanding.	1. Structure group tasks; make children's strategies public; encourage children to note others' contributions to their learning
2. The teacher is in charge of imparting knowledge. The rewards for developing mathematical expertise are external and are often postponed until the future.	2. Mathematics involves learners in constructing meaning for themselves. The rewards for developing expertise are intrinsic.	2. Encourage interaction, revisiting, extending (Schwartz 1996); involve students through student-authored problems, mathematics journals, mathematics "publications"
3. Problems are solved in a swift, prescribed manner.	3. Problems are solved through flexible use of multiple strategies. The time required to solve problems depends on the complexity of the problem.	3. Encourage strategy sharing, problem-posing investigations, extended explorations, mathematics journals (Whitin and Whitin 2000)
4. Mathematics is unrelated to other subjects.	4. Mathematics has real-life application across the curriculum and in contexts outside school.	4. Emphasize content-related problems (e.g., science), problems inspired by children's literature, student-authored problems

Figure 4

A student's visual depiction of the value of sharing ideas in mathematical problem solving



and other problem-posing explorations also helped dispel the notion that all mathematical proficiency is universally equated with the speed of generating a solution.

Finally, problem-solving opportunities arose in contexts outside mathematics class. Students gathered, represented, and analyzed data to make decisions about the ideal seed mixture to place in the class bird feeders (Whitin and Whitin 1999). While studying geology in science, the children used nets to build models of crystals, a process that afforded them the opportunity to apply geometric principles and terminology to the natural world (see **fig. 5**). In addition, the teacher regularly read aloud mathematics-related children's literature to demonstrate mathematical connections within a wide variety of contexts, initiate investigations, and inspire the children's writing. The changes in children's views about the usefulness of mathematics, as well as other attitudes and dispositions, were later reflected in their end-of-the-year assessment.

The Survey as Post-Assessment: Reflection and Evaluation

At the end of each year, the children completed the survey as a post-assessment. Usually the same survey format was used for both the pre-assessment and the post-assessment, but in the final year the post-assessment survey was slightly modified. Question 4—"How can math help you?"—was changed to "To think mathematically means ..." so that the children would state more directly their definitions of mathematical activity. Two new prompts were added: "When you write and draw about math ..." and " 'What if' in math. ...." The first would ensure that the children address multiple forms of representation and communication, while the second referred to problem-posing experiences (Brown and Walter 1990). Both questions were included as a means to evaluate the effectiveness of the instructional modifications made to address the needs identified on the fall surveys. The examples in **figure 6** illustrate trends in the end-of-the-year assessments.

These examples of responses show a wider variety than those from the fall surveys. This range suggests that over the course of the year, the children developed more individualized mathematical identities as well as the confidence to express themselves. One of the sharpest contrasts with the initial surveys is that the later surveys contain almost no references to the teacher. For a student facing a difficult problem, asking "someone to help me" implies peers as well as adults. This student also shows responsibility by adding, "I'll do the rest." In this case, "help" does not mean that "someone else will do the work for me." The student who mentioned the teacher directly included other alternatives as well. Responses such as "use your own or someone else's strategy" and "Math is easy when there are groups or partners" also show an appreciation for collaborative thinking. In fact, as a whole, the children used the pronoun "we" in phrasing their answers to various prompts. This subtle shift in language from the fall surveys further implies a collaborative spirit.

In addition to showing less dependence on the teacher, the students showed more resourcefulness in their attitudes about problem solving. The response "make it into an easy math problem" suggests the strategy of simplifying the problem, while "trying another problem to help solve that problem" and "relate other math to it" show students' awareness of connections among mathematical ideas. The child who noted "I write down what I think" is aware that writing is a tool for reflection and discovery.

Sample responses to two of the revised and new questions are shown in **figure 7**. The collection of statements implies active construction of mathematical meaning. Thinking mathematically incorporates strategic thinking ("math strategies"), the ability to assume multiple perspectives or pose

Figure 5

While studying geology in science, the children used nets to build models of crystals, a process that afforded them the opportunity to apply geometric principles and terminology to the natural world.

5a. Building a model of a calcite crystal

5b. Comparing a calcite crystal with its model

problems (“say a lot of things about one question”), ownership (“make up creative problems”), and responsibility for one’s own learning (“be energetic and serious about your attitude and thinking”).

Some responses to the new question “ ‘What if’ in math ...” revealed an appreciation for engaging in mathematical investigations—for example, “everything would be more of a challenge and a mystery, math would be even more fun.” Interestingly, the child who initially responded to the prompt “How can math help you?” with the abstract example of “wanting to do something with 2 numbers” commented in the spring that “you can use math with almost everything.” In contrast to earlier comments about “getting an A” and benefiting from mathematics “in college,” these comments convey a sense of mathematical activity as intrinsically rewarding. Thus, analysis of the post-assessment surveys provided documentation of individual children’s growth as well as trends in the classroom community. This feedback was valuable in the ongoing process of refining teaching throughout the four years of this study.

Children’s attitudes and dispositions play a vital role in mathematics classrooms. The survey described here suggests one way to gain a window into children’s existing beliefs. Given that information, teachers can better make instructional plans to help their students become more confident, enthusiastic, and autonomous learners.

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Figure 6

Typical student responses from post-assessment mathematics surveys

1. **To be good in math, you need to ... because ...**
   "try hard and correct yourself because you would have a hard time if you don't"
   "have your own or someone else's strategy"
   "be able to solve puzzles and be able to make puzzles because it means you know what math is"
   "study on what you do good because then you will do a lot better"
2. **Math is hard when ...**
   "you don't have a strategy and you can't find a strategy"
3. **Math is easy when ...**
   "you really understand it"
   "you have had experience"
   "there are groups or partners"

...

6. **If you have trouble solving a problem, what do you do?**
   "If it is times I do plus. If it is division I do times."
   "I try my hardest and write down what I think."
   "I relate other math to it and work from there."
   "I ask someone to help me a little and I'll do the rest."
   "Think slow so you will not be confused and you might need help from your teacher or use paper."
   "You can look at a hard problem and make it into an easy math problem."

Figure 7

Typical student responses to sample revised and new survey questions

When you write and draw about math ...
"if you draw a picture, then you will find the answer"
"you can understand it better"
"it puts new thoughts in your head"
"you are showing how you think in math"
"I have a feeling I will make lots of connections"

To think mathematically means ...
"to think hard about your math and make up creative problems"
"you use math strategies to solve a problem"
"you can say a lot of things about one question"
"to be energetic and serious about your attitude and thinking"

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Reflect and Discuss:

The Mathematics Survey: A Tool for Assessing Attitudes and Dispositions

Reflective teaching is a process of self-observation and self-evaluation. It means looking at your classroom practice, thinking about what you do and why you do it, and then evaluating whether it works. By collecting information about what goes on in our classrooms and then analyzing and evaluating this information, we identify and explore our own practices and underlying beliefs.

The following questions related to "The Mathematics Survey: A Tool for Assessing Attitudes and Dispositions" by Phyllis Whitin are suggested prompts to aid you in reflecting on the article and on how the author's ideas might benefit your own classroom practice. You are encouraged to reflect on the article independently as well as discuss it with your colleagues.

- **What is the relationship between attitudes and dispositions and mathematical proficiency?**
- **How do your students' comments and actions in the classroom suggest their attitudes and dispositions? Share your observations and analysis with your colleagues.**
- **What strategies do you use to foster students' development of positive attitudes and dispositions?**
- **Children's views of geometry or data analysis are sometimes very different from their views of number or algebra. What questions would you use to assess students' attitudes and dispositions toward the next mathematics unit you are scheduled to teach? How might the data change how you go about teaching the unit?**
- **Teachers, particularly novice teachers, tend to rely on lesson planning formats to consider the important elements of the lesson. How might one modify the lesson plan format to remind teachers that attention to issues of attitudes, confidence, and collaboration are important?**

You are invited to tell us how you used "Reflect and Discuss" as part of your professional development. The Editorial Panel appreciates the interest and values the views of those who take the time to send us their comments. Letters may be submitted to *Teaching Children Mathematics* at **tcm@nctm.org.** Please include "Readers' Exchange" in the subject line. Because of space limitations, letters and rejoinders from authors beyond the 250-word limit may be subject to abridgement. Letters also are edited for style and content.